LLNL Environmental Restoration Division Standard Operating Procedure	TITLE: Drilling
APPROVAL Date _____ _____ Livermore Site Deputy Program Leader	PREPARERS: J. Gardner*, S. Gregory, J. Hoffman*, and S. Nelson* REVIEWERS: R. Bainer, L. Berg*, T. Carlsen, R. Devany*, and M. Dresen*
APPROVAL Date _____ _____ Division Leader CONCURRENCE Date _____ _____ QA Implementation Coordinator	PROCEDURE NUMBER: ERD SOP-1.3 REVISION: 2 EFFECTIVE DATE: December 1, 1995 Page 1 of 17

***Weiss Associates**

1.0 PURPOSE

To ensure acceptable, consistent drilling procedures for ground water investigations that include borehole logging and sampling and monitor well, extraction well, or piezometer installation.

2.0 APPLICABILITY

This procedure is applicable for all personnel performing drilling operations, and shall be fully reviewed prior to conducting these activities.

3.0 REFERENCES

3.1 Barcelona, M. J., J. P. Gibb, J. A. Helfrich, and E. E. Garske (1985), *Practical Guide to Ground Water Sampling*, U.S. Government Printing Office, EPA/600 2-85/104.

3.2 Department of Water Resources (1981), *Water Well Standards: State of California,* California Resources Agency, Bulletin 74-81.

4.0 DEFINITIONS

4.1 Biological/Ecological Survey

For Site 300, a mandatory survey conducted by a trained biologist to inspect an undisturbed area for endangered species or sensitive habitats prior to conducting environmental activities.

4.2 Flame Ionization Detector (FID)

A portable field instrument used for the quantification of organic compounds ranging from methane to aromatic compounds such as benzene. The FID works by ionizing molecules by a hydrogen flame, and measuring the current generated. The measured current is directly proportional to the number of ionized molecules, and so the concentration of the compound(s) can be determined. As the organic compounds burn, positively charged, carbon-containing ions are produced and are collected by a negatively charged collecting electrode. The current produced is directly proportional to the compound concentration. Due to the use of the flame, this instrument is less sensitive to moisture in the vapor stream than the photoionization detector. The FID is usually calibrated against methane, but can also be calibrated using other compounds.

4.3 Photo Ionization Detector (PID)

A portable field instrument used to quantify purgeable aromatic compounds such as benzene, toluene, and xylene in vapors, but is also useful for other organic compounds. The PID is most effective on unsaturated compounds containing double bonds. The PID works by directing ultraviolet (UV) light onto the molecules, ionizing them, and measuring the current generated. The measured current is directly proportional to the number of ionized molecules, and so the concentration of the compound(s) can be determined. It is usually calibrated against isobutylene or benzene, but can be calibrated using a compound of interest such as trichloroethene (TCE). However, this devise is not compound specific and its measurements represent an aggregate concentration of all compounds that are ionized and detected. This device is sensitive to moisture, therefore moist vapor streams should be analyzed using an alternate instrument such as FID.

5.0 RESPONSIBILITIES

Note: The following responsibilities (Sections 5.1–5.5) are listed by the appropriate level of authority to ensure that proper representation for all procedures and regulations related to this SOP are met.

5.1 Division Leader

The Division Leader's responsibility is to ensure that all activities performed by ERD at the Livermore Site and Site 300 are performed safely and comply with all pertinent regulations and procedures, and provide the necessary equipment and resources to accomplish the tasks described in this procedure.

5.2 Hydrogeologic Group Leader (HGL)

The HGL's responsibility is to ensure that proper procedures are followed for activities (i.e., drilling, borehole logging and sampling, monitor well installations and development) and to oversee the disposal of all investigation derived wastes.

5.3 Drilling Supervisor (DS)

The DS plans and coordinates all drilling related activities, ensures that all drilling related activities are performed safely and efficiently (using the proper procedures), and that the data generated from these activities are valuable and representative of the true geologic or physical conditions within the borehole. Such activities may include operation of logging equipment, soil sampling, well installation, and development. The DS is also responsible for:

5.3.1 Coordination of the drilling contractor schedules and equipment needs:

- Coordinate the schedules of multiple drill rigs with the drilling contractor.
- Provide the Work Plan to the drilling contractor and answer questions.
- Negotiate the arrival/start date and drill type.
- Monitor the progress of the drilling and anticipate changes in equipment needs (e.g., auger rig, air-mist rig, mud-rotary rig).

5.4 Drilling Coordinator (DC)

5.4.1 The DC provides the interface between the DS and the field activities including:

- Oversight of the Drilling Geologist (DG) and field activities.
- Coordinate the DG's work load.
- Obtain the necessary equipment, supplies, and release numbers from the Technical Release Representative (TRR) for the drilling contractor.
- Provide guidance and training.
- Inform the DG about procedural changes in areas related to drilling (e.g., changes in sampling requests, cuttings disposal issues, new forms, etc.).
- Provide technical input to the DG and Study Area Leader (SAL)/Facility Task Leader (FTL).
- Review borehole and geophysical logs.
- Monitor drilling progress on a daily basis.
- Interact with the Quality Assurance (QA)/Quality Control (QC) officer on drilling and soil sampling issues.
- Estimate the contaminants likely to be present, and the quantity of drilling spoils that may be generated.

5.4.2 During the startup of a new drilling phase, the DS works with the DC and SAL/FTL to:

- Create and finalize all related drilling documents (i.e., the Work Plan and Sampling Plan).
- Work with the SAL/FTL to establish drilling locations, schedules, and budgets for each well.
- Determine the protective equipment necessary for personnel in the field.
- Make well completion decisions and specify the well construction details from the SAL/FTL and Hydrogeologic Group Leader (HGL) input.
- Act as the liaison between the SAL/FTL and the DG.
- Coordinates all necessary biological/archeological surveys prior to drilling. Results of the surveys should be forwarded to the SAL/FTL and Environmental Chemistry and Biological Group Leader (ECBGL).

5.5 Drilling Geologist (DG)

The DG's responsibility is to ensure that drilling activities are carried out according to the specifications designated in the Work Plan, Sampling Plan, Site Safety Plan (SSP), Operation Safety Procedure (OSP), and Standard Operating Procedure (SOP). Additionally, the DG must oversee and document all aspects of the drilling/field investigation, including lithologic and geophysical data, well completion and development specifications, activities of the drillers, sampling and workspace monitoring details. The DG is also responsible for:

5.5.1 Site Preparation and Supply Ordering. The DG must:

- Review the Work Plan prepared by the SAL/FTL and DC, and discuss any questions.
- Assemble all necessary materials, including personal protective equipment (PPE).
- Supply tracking and ordering requests.
- Confirm that all necessary security arrangements have been made to permit site access (e.g., schedule escorts, notify the building coordinator of planned activities, arrange for opening of locked gates).
- Confirm that utility locator and mud pit excavations (if necessary) have been arranged with the field personnel.
- Discuss LLNL site planning requirements and utility lines with field personnel and drillers before drilling begins.

5.5.2 Site Safety

- Supply the SSP, OSP, and SOPs to all workers who enter the drill site.
- Monitor and record work space conditions with appropriate monitoring equipment (including FID, PID, etc.) during drilling activity.
- Confirm that appropriate fencing, warning signs, barricades, animal exit ramps (for mud pit), borehole cover and protection are in place.
- Discontinue work and contact the DC if chemical or physical hazards are encountered.

5.5.3 Field Activities

- Coordinate schedules/actions with field personnel.
- Research site hydrogeology to estimate key parameters (e.g., sample target zones, hydrostratigraphic unit depths and thicknesses, and types of contaminants).
- Obtain a field logbook from the Data Management Group (DMG).
- Calibrate and record calibration information for all monitoring equipment.
- Confirm all sample naming conventions with DMG.
- Collect and document samples.
- Handle all changes and corrections to chain-of-custody (CoC) forms and/or analytical requests.
- Inform the DC, SAL/FTLs, and DMG of any sampling or sampling documentation irregularities.
- Report any deviations from the SSPs, OSPs, or SOPs to the QA/QC Officer.
- If SOPs are violated, a nonconformance report is to be completed and submitted to the QA/QC officer.
- Report missed turnaround times for analytical sample results to QA/QC Officer.
- Confirm that drilling waste analytical results are consistent with the chosen disposal method.
- Decontaminate all sampling equipment.
- Provide frequent updates and documentation of field activities to the DC, HGL, and SAL/FTL.

5.6 Environmental Chemistry and Biology Group Leader (ECBGL)

The ECBGL's responsibility is to provide biological or chemical information and expertise (i.e., biological surveys, water supplies, chemical field instruments, etc.).

5.7 Field Personnel

The field personnel's responsibilities are to conduct all ERD field work that complies with all established operational and safety procedures, and to inform the HGL when the procedures are inappropriate.

Activities the field personnel are responsible to perform (but are not limited to) are to:

- Collect, store, and ship borehole samples to analytical laboratories.
- Drill, complete wells, log boreholes, and properly develop wells to allow the highest yield and the highest quality samples.
- Communicate the performance of development activities to the HGL and DC to allow for modification of the development methods to improve well yield.

5.8 Site Safety Officer (SSO)

The SSO's responsibility is to ensure the safety of ERD's ongoing operations and facilities and work performed. The SSO's responsibility is to receive the details of potential hazards and procedures for all field activities. The SSO directs this information to the LLNL Hazards Control Department to determine if a new Operational Safety Procedure (OSP) is required, thus assuring that an existing OSP addresses all ES&H issues for each operation.

5.9 Study Area Leaders (SAL)/Facility Task Leader (FTL)

The SAL/FTL are responsible for the overall investigation, planning, assessment, and remediation within a study area.

5.10 Technical Release Representative (TRR)

The TRR is responsible for the acquisition and administration of blanket contract releases for the procurement of goods and services. The TRR has the authority to obligate LLNL for payment of goods and services, delegated by the LLNL Business Manager through the LLNL Procurement Department.

5.11 Treatment Facility Hydrogeologist (TFH)

The TFH is responsible for helping the FTL determine borehole location and target zone for completion.

6.0 PROCEDURES

The drilling process should minimally alter the medium that is being investigated. It is essential that the drilling process not introduce hazardous or foreign substances into the borehole or create conduits that facilitate the spread of existing contaminants. Various methods are used for drilling including hollow-stem augers, mud rotary, air or air-mist rotary. In areas of multiple water-bearing zones at Site 300, conductor casings may be used to isolate each encountered water-bearing zone.

6.1 Office Preparation

6.1.1 The DC shall ensure that:

A. Site access has been coordinated and, if applicable, written permission has been obtained for entrance onto private property.

B. Boring or well drilling permits required by state or local authorities have been obtained and procedures for compliance with any and all state or local regulations with regard to the submission of well logs, samples, etc. are in place.

C. Underground utilities have been identified using Plant Engineering plans and underground utility surveys.

D. The TRR has been provided with an estimate of sampling requirements prior to obtaining a release number.

E. For Site 300, ecological surveys have been conducted within the previous 60 days for endangered species if the drilling location is at a previously undisturbed site. Check with the ECBGL if unsure of biological survey status.

F. For Site 300, obtain the approval of Site 300's Plant Engineering prior to drilling. For Livermore Site, the SSO, Building/Trailer Coordinator, and Site and Space Planning of Plant Engineering have been notified and given their approval of the drilling location.

6.1.2 The DC should knows the scope of work and purposes of borings/wells.

6.1.3 The DG obtains materials listed in the Equipment Checklist (Attachment C) and obtain appropriate personal protective equipment (PPE) per SOP 4.1, "General Instructions for Field Personnel."

6.1.4. The DC reviews associated SOPs and pertinent sections of the Site Safety Plan, and discuss the need for PPE with the SSO.

6.1.5 The DC coordinates schedules/actions with the SAL/FTL, DG, and DS.

6.1.6. The SAL/FTL, DC, and DG reviews existing local hydrogeologic data (such as well logs, contaminant distribution data, and hydraulic test data), and discuss strategies.

6.1.7 Ensure that expected conditions that will be encountered are included in the drilling OSPs. Any expected or suspected conditions, either of a chemical or physical nature, which are not included in the drilling OSPs necessitate the production of an OSP addendum to address these issues.

6.2 Field Preparation

6.2.1 Verify that underground utilities have been surveyed and that drilling activities will not interfere.

6.2.2 For Site 300, stake or mark the location of the proposed borings in areas that are not traversed by utility transmission ways.

6.2.3 Ensure the working areas are cleared of all brush and minor obstructions, as necessary, and check for the location of the fire extinguisher(s) at the work site.

6.2.4 Prior to initiation of drilling, ensure decontamination of all downhole drilling and sampling equipment, including the back of the drilling rig (SOP 4.5, "General Equipment Decontamination").

6.2.5 If water is introduced into the borehole, the source(s) of water must be approved by the ECBGL prior to field operations. The criteria used to determine if water is acceptable are previous laboratory analyses demonstrating the water is free of contaminants of concern. The source(s) of introduced water shall be documented in Attachment A and B.

6.2.6 Follow the instructions pertaining to conducting field work per SOP 4.1.

6.3 Operation

6.3.1 Use the Borehole/Well Construction Log (Attachment A) to document field information and comments. Complete all lines on the forms. Use the letter designation "NA" (not applicable) or "NK" (not known) in all blank spaces. If some steps or procedures are not performed as described, state the reason on the Borehole/Well Construction Log. The instructions for this form are included in SOP 1.1, "Field Borehole Logging." Also complete a chronology of daily events on the Daily Field Report (Attachment B).

6.3.2 Borehole logging must conform to SOP 1.1 procedures. Borehole sampling for subsequent chemical analysis must conform to SOP 1.2, "Borehole Sampling of Unconsolidated Sediments and Rock."

6.3.3 Ensure that no solvents, light hydrocarbon-based lubricants, or paints are present or applied to downhole drilling tools or samplers. The lubricants "King Stuff" and "Green Plus" are acceptable for drill rod threads. The Material Safety Data Sheets for the lubricants are on file with the ECBGL.

6.3.4 Ensure that the back of the drilling rig is free of any mud, leaking hydraulic lines, and excess grease that could be dislodged during drilling. If a leak occurs during drilling, terminate drilling activities until the leak is repaired.

6.3.5 If mud-rotary drilling is used, ensure that the drilling fluid is composed of approved water (Section 6.2.5 of this SOP), discussed below, and pure bentonite containing no polymers or chemical additives of any kind. Record the brand name and manufacturer of the bentonite used on Attachment A and B.

6.3.6 The supply water should be screened using an FID or PID of trihalomethanes. This field reading shall be known as the Source Water Background Value and shall also be recorded on the field log.

6.3.7 When there is insufficient historical data, the DG has the option of obtaining a water quality analysis (EPA601) from the water-supply well or water-supply source that will be used for the makeup water once a week while drilling. The DG shall sum the reported concentrations of chloroform, bromodichloromethane, chlorodibromomethane, and bromoform reported in the water quality analysis. This sum shall be recorded as the Source Water Trihalomethane Concentration on the Borehole/Well Construction Log (Attachment A).

6.3.8 Samples of the drilling mud should be field screened using the PID or FID prior to entering lower hydrogeologic units to prevent possible cross-contamination between shallow and deeper zones.

6.3.9 If air-rotary drilling is used, ensure that air systems include an in-line filter to remove all oil from the compressed air.

6.3.10 Regularly monitor drill cuttings and work area with a PID or FID. If the readings exceed the time-weighted average (TWA) values, or exceed half of the threshold limit values (TLV), for known or suspected chemicals, shut down the operation and contact the DS, SSO, or DC, who will notify the appropriate Environmental

Safety and Health (ES&H) Team, Operational Safety Division, and LLNL Hazards Control Department.

6.3.11 If water is encountered in the borehole in which mud was not used, a bailed sample may be requested to gain information about potential contaminants. Samples should be named according to SOP 4.2, "Sample Control and Documentation." Record sampling information including the sample depth on the Borehole/Well Constructions Log. Follow other appropriate SOPs such as SOP 2.4, "Sampling Monitoring Wells with a Bailer" and SOP 4.3, "Sample Containers and Preservation."

6.3.12 Conduct work in compliance with all regulations with regard to drilling safety and underground utility detection. Planned borehole locations should be moved if required for safety considerations.

6.3.13 Ensure that, a daily driller's report is maintained and submitted by the drilling contractor. The report should give a complete description of the number of feet drilled, number of hours on the job, shutdown due to breakdown, length of casing set, materials used, and other pertinent data. The DG assigned to the rig is responsible for verifying that the report is accurate prior to submission to the DC.

6.3.14 Handle all soil cuttings and waste materials per SOP 1.8, "Disposal of Investigation-Derived Wastes (Drill Cuttings, Core Samples, and Drilling Mud)."

6.3.15 If temporary casing is needed (for reasons such as lost circulation or excessive caving), decontaminate the casing as outlined in SOP 4.5. The use of temporary casing is well-specific, and its use should be decided upon by the DG, DS, and DC.

6.3.16 The abandonment of any boring or well should be in accordance with appropriate state regulations and follow the procedures in SOP 1.7, "Well Closures."

6.3.17 Drilling personnel must wear the following minimum physical protection: hard hat, safety glasses, steel-toed boots, and hearing protection. Additional safety equipment may be specified by the SSO and/or appropriate ES&H Team of the LLNL Hazards Control Department.

6.3.18 Store equipment at the site neatly to avoid potential tripping hazards. Place decontaminated equipment on top of a plastic ground covering. Tape or rope off the area.

6.3.19 If the borehole is left unattended at any time, the DG should ensure that the borehole is covered and protected.

6.4 Field Post Operation

6.4.1 Decontaminate all equipment as noted in SOP 4.5.

6.4.2 Return site to its original condition using best reasonable efforts.

6.5 Office Post Operation

6.5.1 For disposition of drilling wastes, refer to SOP 1.8.

6.5.2 Deliver original data forms to the DMG for storage and copies to the DC for review and distribution.

7.0 QUALITY ASSURANCE RECORDS

7.1 Borehole/Well Construction Log

7.2 Chain-of-Custody Form

7.3 Field Logbook

7.4 Daily Field Report

8.0 ATTACHMENTS

Attachment A—Borehole/Well Construction Log

Attachment B—Daily Field Report

Attachment C—Equipment List

Attachment A

Borehole/Well Construction Log

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BOREHOLE / WELL CONSTRUCTION LOG

Page ____ of ____

BOREHOLE LOCATION	Project:	Borehole / Well No:
		Job No:
	Logged By:	Edited By:
	Project Manager:	Drill Rig:
	Drilling Contractor:	
	Driller / Helper:	
	Drilling Method:	Sample Method:
	Hammer Weight / Drop:	Bentonite / Gel Product Used:
	Borehole Diameter, Pilot:	Final:
	Borehole Started, Time / Date:	Borehole Completed, Time / Date:
	Well Started, Time / Date:	Well Completed, Time / Date:
Notes:	Water Depth	
	Boring / Casing Depth	
	Time	
	Date	

Total Depth:	Casing Depth:
Screened Interval:	
Sand Pack, #3:	#0:
Well Development Method:	
Time: Date:	Flow Rate:
Geophysical Logs, Type:	
By:	Date:

OVA / PID Field Readings (ppm)																
Work Area	Soil / Rock	Sampler Type / Depth	Blows / 6 Inches for RQD	Inches Driven / Inches Recovered	Sample Condition / Time	Sample ID / Depth: _____ Depth F	Analysis	Outer Annulus	Conductor Casing(s)	Well Annulus / Borehole Filler	Well Casing	Depth in Feet	Recovery / Sample Loc.	Contact	LITHOLOGIC DESCRIPTIONS	
												1				
												2				
												3				
												4				
												5				
												6				
												7				
												8				
												9				
												10				

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Attachment A. Borehole/Well Construction Log.

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BOREHOLE / WELL CONSTRUCTION LOG (cont.) Page ____ of ____

OVA/PID Field Readings (ppm)																
Work Area	Soil/Rock	Sampler Type/Depth	Blows / 6 Inches for RQD	Inches Driven / Inches Recovered	Sample Condition / Time	Sample ID/Depth: ____ Depth F	Analysis	Outer Annulus	Conductor Casing(s)	Well Annulus/ Borehole Filler	Well Casing	Depth in Feet	Recovery / Sample Loc.	Contact	Project / Job No.:	Borehole/Well No.:
															Notes:	
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Attachment A (Continued).

Attachment B

Daily Field Report

DAILY FIELD REPORT

Date:	**Project(s):**
Name:	**Project Manager:**
Vehicle:	**Job Number:**

PID/OVA Calibration: Yes_____ No_____	**Daily Site Safety Meeting Time:_________**
Time:_________	

Time	Activity

jcm

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Attachment B. Daily Field Report.

Attachment C

Equipment Checklist

Equipment Checklist

_____ Sample containers/labels
_____ Appropriate clothing (i.e., coveralls, steel-toed safety shoes, gloves)
_____ Company ID sign for vehicle (if applicable)
_____ Field forms (i.e., CoC form, Borehole/Well Constructions form)
_____ Any applicable permits
_____ Field notebook
_____ Hard hat
_____ Safety glasses
_____ Cooler with ice
_____ 300-ft weighted tape
_____ Rock hammer
_____ Steel measuring tape with engineering scale
_____ Steel spatula
_____ Hearing protection
_____ Core boxes and trays, black indelible marking pens
_____ Water-level meter
_____ First aid kit
_____ Fire extinguisher
_____ Detergents (Alconox, TSP)
_____ Deionized water
_____ Buckets and brushes
_____ Document control logbook
_____ PID or FID
_____ Barricades
_____ Signs listing responsible persons (if applicable)
_____ Caution tape
_____ Brunton compass
_____ Measuring wheel
_____ Munsell soil color chart
_____ Sampling gloves (vinyl and nytrile)
_____ Duct tape
_____ Soil sample tubes
_____ Glass jars
_____ Aluminum foil
_____ Teflon tape (4 in. width)
_____ Bailers (Teflon or stainless steel)
_____ Drums